

EFFECT OF HOST PHENOLOGY ON OVIPOSITIONAL PREFERENCE OF WINTER FORM PEAR PSYLLA (HOMOPTERA: PSYLLIDAE)

L.C. STUART, B.A. BUTT¹, AND R.L. BELL
 U.S. DEPARTMENT OF AGRICULTURE
 AGRICULTURAL RESEARCH SERVICE
 APPALACHIAN FRUIT RESEARCH STATION
 45 WILTSHIRE ROAD
 KEARNEYSVILLE, WV 25430

ABSTRACT

In free-choice assays using budwood at similar stages of leaf emergence, winter form (WF) pear psylla (*Cacopsylla pyricola* Foerster form *simulans*) showed no ovipositional preference for psylla-susceptible 'Bartlett' (*Pyrus communis* L.) over psylla-resistant W6 (*P. ussuriensis* Maxim.) or NY10353 (*P. ussuriensis* x *P. communis* hybrid). After budbreak, WF psylla oviposited on the host with foliage in the most advanced stage of leaf emergence.

Key Words: *Cacopsylla pyricola* Foerster, pear psylla, ovipositional cues, host plant resistance, behavior.

The pear psylla, *Cacopsylla pyricola* Foerster, exists in two distinct seasonal forms: form *typica*, or summer form, (SF) and form *simulans*, or winter form (WF). The WF psylla overwinter as adults in reproductive diapause, frequently outside the orchards (Burts, 1970; Fye, 1983). Oviposition begins on the reproductive host, pear (*Pyrus communis* L.), early in the spring in response to increasing daylength (McMullen and Jong, 1976). Release from diapause is coincident with tree phenology, beginning shortly before budbreak (Burts, 1970). Host plant location is an essential step in the repopulation of orchards.

Psylla-resistant genotypes of *Pyrus ussuriensis* Maxim. (Westigard et al., 1970) and *P. ussuriensis* x *P. communis* hybrid origin (Harris, 1973) have been identified in which ovipositional non-preference by SF is an important modality of host resistance. Harris (1973) also reported that differences in ovipositional preference exhibited by WF psylla between resistant and susceptible hosts were small, and suggested that differences in phenology may be involved. Vegetative budbreak and bloom of trees of this genetic lineage is three to ten days earlier than that on *P. communis* cultivars, which, as a group, are susceptible to the pear psylla. Oviposition by WF increases in response to budbreak and foliar expansion (Smith, 1965). On Asian, domesticated European, and local landrace cultivars of apple and pear, a European pear psyllid, *Cacopsylla pyri* L., and an apple psyllid, *Psylla melanoneura* Foerster form *taurica*, oviposited first on the genotypes which came out of dormancy earliest (Lazarev, 1974).

In these field studies, differences in host phenology were confounded with genotype, particularly when different host species were involved. Because terminal buds can influence the emergence of buds basal to them, a preliminary experiment was conducted to investigate this matter of technique. A subsequent experiment was then designed to investigate the contribution of host phenology to ovipositional performance by WF pear psylla through the early stages of leaf emergence.

MATERIALS AND METHODS

Experiment I. We tested the hypothesis that WF would oviposit preferentially on dormant budwood of a psylla-susceptible *P. communis* cultivar, 'Bartlett', over a resistant wild-type clone, *P. ussuriensis* W6 (W6) (Westigard et al., 1970). The experiment was designed as a free-choice paired comparison. Dormant budwood was collected from the Appalachian Fruit Research Station, Kearneysville, WV, orchard on 14 March 1985. Presence of a terminal bud may delay the opening of lateral buds and thereby influence psylla preference. Therefore, we used ten matched pairs of 'Bartlett' and W6 budsticks, five pairs with and five pairs without terminal buds. All budsticks had three lateral buds. The budsticks were placed in individual vials of water. Each pair ('Bartlett' and W6) was placed in a cylindrical plastic cage with four

¹ Present address: International Atomic Energy Agency, Insect and Pest Control Section, Wagramerstrasse 5, P.O. Box 200, A-1400, Vienna, AUSTRIA

male and four female adult WF which had been field-collected the same day. Cages in this and subsequent experiments were placed in a rearing room at 25C, with a photoperiod of 16:8 (L:D). Egg counts were made on day six after insect removal. Data were analyzed using paired 2-tailed t-tests.

Experiment II. This experiment was designed as a set of six dual-choice comparisons: three between susceptible and resistant hosts at the same stages of bud development; two between stages that would occur naturally with the resistant host further developed than the susceptible host; and one between the resistant host in dormant condition and the susceptible host at budbreak, a situation not occurring naturally. The final comparison was made to ensure that choice was based on bud development and not host genotype.

The susceptible host was 'Bartlett' and the resistant was NY10353 (NY), a *P. ussuriensis* x *P. communis* hybrid shown to be resistant by greenhouse and field counts of nymphs (R.L. Bell, unpublished data; R.C. Lamb, personal communication). Budbreak of NY occurs about 5-7 days earlier than 'Bartlett' in the field. Fully-dormant budwood was collected from the orchard in mid-February 1987, and held in storage at 2C. Because budbreak proceeds more rapidly on NY than on 'Bartlett', bud stages were matched by removing 'Bartlett' budsticks from cold storage in advance of NY. Terminal buds were removed, because budbreak of lateral buds was observed to occur more uniformly in their absence. Adult WF were collected from the field by beating tray and aspirator on 14 April 1987, held in a refrigerator at 3C overnight and introduced to budsticks the following day.

Each choice test was replicated 10 times and consisted of a 'Bartlett' and a NY budstick, each with five buds. Budsticks were placed in individual vials of water, and each pair was enclosed in a plastic cylindrical cage with two male and two female WF. Eggs were counted after day five in the first five comparisons. In the final comparison, 'Bartlett' at budbreak vs. dormant NY, eggs were counted after three days to avoid the loss of uniform bud development, which had begun on about day three in previous comparisons. Square root transformation failed to improve normality and equality of variances in all comparisons, and, therefore, untransformed data were analyzed by paired 2-tailed t-tests.

Although we attempted to match each pair of budsticks as closely as possible in both size and the condition of the five buds, this uniformity could not be maintained. Within the five-day test period, leaf emergence progressed rapidly. Buds which had begun dormant had reached green tip, and buds which were initially at budbreak and green tip were at varying stages of leaf emergence and expansion, with NY buds developing faster than 'Bartlett' buds in most cases. Therefore, the data was also separated into three categories according to the relative stage of leaf emergence at the end of the experiment: NY equal to 'Bartlett', NY more advanced than 'Bartlett', and 'Bartlett' more advanced than NY.

RESULTS AND DISCUSSION

Experiment I. W6 buds, particularly the terminals, developed faster than 'Bartlett' buds. On intact budsticks, more eggs were oviposited on W6 terminal buds, which had ca. 1 cm of foliage, than on the lateral buds (Table 1; Prob. $> t/ = 0.07$). More eggs were found on the most distal lateral buds. There was no significant difference between lateral and terminal buds of 'Bartlett' (Prob. $> t/ = 0.77$). Eggs were deposited on the foliage or on tops of adjoining bud scales. On dormant buds, eggs were found on and around bud scales and in cracks near buds. The data shown for mean number of eggs on lateral buds represents the total eggs on all three lateral buds of each budstick. In no case were more eggs found on a single lateral bud than on the terminal.

Table 1.

Mean number of eggs \pm standard error oviposited by winter form pear psylla on 'Bartlett' and *Pyrus ussuriensis* W6 (W6) budsticks with and without terminal buds.^{1/}

Host	Budsticks with terminal buds			Budsticks without	
	3 Lateral buds	Terminal buds	Total	terminal buds	Overall
Bartlett	56.2 \pm 13.2	53.0 \pm 13.9	109.2 \pm 24.9	79.4 \pm 26.2	94.3 \pm 31.5
W6	41.8 \pm 10.8	139.6 \pm 38.2	181.4 \pm 40.3	198.2 \pm 49.4	189.8 \pm 91.1
Difference (Bartlett-W6)	14.4 \pm 7.5	-86.6 \pm 36.5	-72.2 \pm 29.7	-118.8 \pm 54.4	-95.5 \pm 30.2
Prob. $>/t/^{2/}$.13	.08	.07	.09	.02

^{1/} Two six-day free-choice tests, five replications each.

^{2/} Null hypothesis, (H_0): 'Bartlett'-W6 = 0 at $p = 0.05$, 2-tailed paired t-test.

Where terminals were removed, W6 buds all opened rapidly. By day six, they showed ca. 2.5 cm of foliage, and new leaves were beginning to separate and expand, while 'Bartlett' buds were only slightly swollen with no foliar tissue showing. Slightly more eggs were deposited on W6, either directly on foliar tissue or on nearby bud scales, than on the still-dormant 'Bartlett' (prob. $>/t/ = 0.09$). However, one 'Bartlett' budstick developed faster than its paired W6 and showed foliage at all nodes. The 168 eggs deposited on that single budstick accounted for 42% of all eggs found on 'Bartlett'. The corresponding W6 had 113 eggs. There were no significant differences in oviposition between budsticks with or without terminals (Prob. $>/t/ = 0.49$). Therefore, the data were combined to test for preference between hosts.

WF did not prefer the budwood of the susceptible cultivar 'Bartlett' for oviposition. Instead, they chose oviposition sites on buds where foliage appeared, even if this was on the moderately-resistant W6. This could be interpreted to mean that W6 was more attractive for oviposition. However, the one replication in which eggs were concentrated on a 'Bartlett' budstick which was further advanced also leads to the hypothesis that attraction to foliage as an oviposition site was more important than other genotypic factors to WF psylla.

Experiment II. Oviposition occurred on budwood of all stages, but was least when buds were dormant at the beginning of the assay (Table 2). Oviposition on both genotypes increased dramatically between the dormant stage and budbreak, and increased again, up to 3-fold between budbreak and green tip. In the 3-day test which began with dormant NY vs. 'Bartlett' at budbreak, only a single egg was found on NY.

Table 2.

Mean numbers of eggs deposited by winter form pear psylla on 'Bartlett' and NY10353 budsticks.^{1/}

Bud stage ^{2/}		Mean number of eggs/budstick \pm se			Prob. $> 1t^{4/}$
Bartlett	NY10353	Bartlett	NY10353	Difference	
D	D	9.5 \pm 3.9	3.7 \pm 1.6	5.8 \pm 3.1	.094
BB	BB	76.2 \pm 21.1	77.9 \pm 19.9	-1.7 \pm 28.9	.954
GT	GT	113.7 \pm 29.8	210.5 \pm 38.0	-96.8 \pm 56.8	.123
D	BB	50.5 \pm 19.0	62.2 \pm 19.9	-11.7 \pm 29.1	.697
BB	GT	41.2 \pm 10.0	184.0 \pm 29.0	-142.8 \pm 32.9	.002
BB ^{3/}	D ^{3/}	17.8 \pm 6.5	0.1 \pm 0.1	-17.7 \pm 6.5	.024

^{1/} In five-day free-choice test with 10 replications, analyzed by bud stage on day 0.

^{2/} D = dormant, BB = budbreak, GT = 1/4" green tip.

^{3/} Three-day test.

^{4/} Null hypothesis (H_0): 'Bartlett' = NY10353; 2-tailed t-test.

When the data were analyzed on the basis of stage of emergence at the end of the experiment, the largest numbers of eggs were found on the host which had the most exposed foliar tissue (Table 3). No significant differences were found between NY10353 and 'Bartlett' where their buds had emerged to the same stage.

Adult pear psylla (WF and SF) show no preference for resistant or susceptible cultivars in either frequency or duration of visitation when foliar conditions are approximately equal (Harris, 1973; 1975). Our study indicated that, in addition, WF showed no ovipositional preference among phenologically similar hosts, from dormancy through early stages of leaf expansion. Instead, WF females were attracted to buds in the most advanced stage of foliar development. Similar observations of other psyllid species on pome fruit (Lazarev, 1974) tend to support the hypothesis that lack of host discrimination early in the season may be a widespread occurrence in psyllids.

Summer form pear psylla have shown ovipositional preferences among host genotypes with fully expanded leaves (Westigard *et al.*, 1970; Harris, 1973; Harris, 1975). This observation is also true when comparing orchard-grown trees of 'Bartlett' and NY (R.L. Bell, unpublished data). SF psylla will oviposit on dormant buds of 'Bartlett' (in laboratory) at a low frequency, and, hence, are behaviorally similar in this respect to WF psylla (Butt and Stuart, 1986).

Our data are consistent with observations that oviposition by WF females increases after budbreak (Smith, 1965). The cue(s) triggering host preference for oviposition may appear or

Table 3.

Mean number of eggs deposited by winter form pear psylla on 'Bartlett' (Bart) and NY10353 (NY) budsticks, analyzed by initial and final bud stage.^{1/}

Initial Bud stage ^{2/}		Final bud stage								
		NY = Bart			NY > Bart			Bart > NY		
Bart	NY	N	Bart	NY	N	Bart	NY	N	Bart	NY
D	D	10	9.5	3.7	0	-	-	0	-	-
BB	BB	8	82.3	73.9	2	52.0	94.0	0	-	-
GT ^{3/}	GT ^{3/}	3	186.0	158.3	6	91.7	225.3	0	-	-
D ^{4/}	BB ^{4/}	2	38.0	30.0	4	10.3	107.5	3	128.3	42.0
BB	GT	0	-	-	10	41.2	184.0	0	-	-
BB ^{5/}	D ^{5/}	0	-	-	0	-	-	10	17.8	0.1
Final bud stage mean		23	60.3	50.6	22	50.3	173.2	13	43.3	9.7
Mean difference ^{6/} ± se		9.7 ± 12.4			-122.9 ± 27.1			33.6 ± 10.9		
Prob.> /t/		.4406			0.0002			0.0098		

^{1/} In five-day free-choice test, 10 replications per initial bud stage.

^{2/} D = dormant, BB = budbreak, GT = 1/4" green tip.

^{3/} One replication dropped due to death of one budstick.

^{4/} One replication dropped due to death of female psylla.

^{5/} Three-day test.

^{6/} Bartlett-NY.

be stronger when foliage develops, because the degree of oviposition is positively associated with the amount of foliar tissue available. The exact basis of this behavior is uncertain, considering the ovipositional preferences exhibited by SF psylla. The WF female psylla may not be capable of discriminating between host genotypes on the basis of the cues affecting SF females. Alternatively, if only fully expanded leaves express these cues, WF do not have the opportunity to discriminate among hosts because of phenological differences.

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LITERATURE CITED

- Burts, E.C. 1970. The pear psylla in central Washington. Wash. Agric. Exp. Stn. Cir. 516. 13 pp.
- Butt, B.A. and C. Stuart. 1986. Oviposition by summer and winter forms of pear psylla (Homoptera: Psyllidae) on dormant pear budwood. Environ. Entomol. 15:1109-1110.
- Fye, R.E. 1983. Dispersal and winter survival of the pear psylla. J. Econ. Entomol. 76(2):311-315.
- Harris, M.K. 1973. Host resistance to the pear psylla in a *Pyrus communis* x *P. ussuriensis* hybrid. Environ. Entomol. 2(5):883-887.
- Harris, M.K. 1975. Greenhouse testing of pears with *Pyrus ussuriensis* lineage for resistance to *Psylla pyricola*. J. Econ. Entomol. 68(5):641-644.
- Lazarev, M.A. 1974. Trophic selectivity of apple and pear psyllas. Byull. Gos. Nikitsk. Bot. Sada 2(1):44-47 (in Russian).
- McMullen, R.D. and C. Jong. 1976. Influence of temperature and host vigor on fecundity of the pear psylla (Homoptera: Psyllidae). Can. Ent. 104:1209-1212.
- Smith, E.H. 1965. The susceptibility of life history stages of pear psylla to oil treatment. J. Econ. Entomol. 58:456-464.
- Westigard, P.H., M.N. Westwood and P.B. Lombard. 1970. Host preference and resistance of *Pyrus* species to the pear psylla, *Psylla pyricola* Foerster. J. Amer. Soc. Hort. Sci. 95(1):34-36.